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REVIEW OF PERFORMANCE STANDARDS FOR RADAR EQUIPMENT

Report of the Correspondence Group

Submitted by Norway

SUMMARY

Executive summary:	This paper presents the work of the Correspondence Group on Radar and presents a draft revised Performance Standards for shipborne Radar Equipment. This revision is intended to consolidate and replace a number of current documents which cover this subject. The presentation of AIS on radar is also included in the Standard. The draft revised Performance Standards are based on the input from contributing parties and the results of user surveys and user conferences held in different countries. The work in the Correspondence Group has been done in close co-operation with the ongoing work in IEC Working Group 1.
Action to be taken:	Paragraph 22
Related documents:	MSC.64(67), A.820(19), A.823(19), A.917(22), COMSAR 5/14, NAV 47/8/2, NAV 47/13, NAV 48/19, MSC 75/22/4, MSC 75/24, SN/Circ.217, NAV 49/9, NAV 49/19, SOLAS Ch. V, Reg. 19

Introduction

1 MSC instructed the NAV Sub-Committee to undertake a review of the performance standards for shipborne radar equipment. Initially the work was programmed to be completed by 2003 to allow its conclusions to be used within the framework of current ITU-R studies, which are due to be completed by 2006. However, NAV 48 invited the Maritime Safety Committee to extend the target completion date for the agenda item "Review of performance standards for radar equipment" to 2004 and MSC 76 agreed to this.

2 The Sub-Committee at its forty-ninth session established a Correspondence Group (CG) in order to promote active discussions and finalization of the work in 2004.

3 The following countries have participated in the CG: Denmark, Germany, Japan, Norway, Poland, Sweden, the United Kingdom and the United States.

For reasons of economy, this document is printed in a limited number. Delegates are kindly asked to bring their copies to meetings and not to request additional copies.

4 This paper presents the work of the CG (annex 1) and proposes a revision to the Performance Standards for Radar and associated plotting and tracking aids (annex 2).

5 Regarding future development, the CG was concerned that the format of the revised performance standard presented in annex 2 - which combines requirements for sensors, processing, function and presentation - may possibly inhibit the future development of these items as separate standards. However, the CG considers that the proposed radar performance standard will not need revision until necessitated by future changes or harmonizations of other related standards, and/or by future technical development. Some time in the future restructuring of this standard may then be desirable, including transfer of sections or paragraphs to other, new or amended standards, but without necessarily having to change the technical requirements.

Background

6 For the foreseeable future, radar will remain a primary tool for safe navigation as the shipborne radar sensor performs its function totally independently of externally-generated signals. Whilst recently developed systems such as AIS have significant potential to complement information provided by radar, they cannot replace it as they are heavily dependant on signals and information from sources external to own ship.

7 X and S band radars are essential tools for maritime safety. Frequency spectrum is an increasingly valuable resource. In future the ITU is likely to require that frequencies allocated to marine navigation radar are used more efficiently, that unwanted emissions are reduced and possibly that frequency bands are shared with other services. Revised Performance Standards must take account of these factors.

8 The basic transmitter technology used in navigation radar has changed little since its invention more than 60 years ago, but developing technology is now presenting new possibilities for fundamental changes. These offer opportunities to improve radar performance and meet future spectrum requirements more economically, provided that Performance Standards can evolve to allow this.

Proposed revision of the Performance Standards

8 A draft revision of the Performance Standards for Radar is given at annex 2. It is proposed that these revised Performance Standards should supersede:

- MSC.64 (67), annex 4, Performance Standards for Radar Equipment.
- A.823(19) Performance Standards for Automatic Radar Plotting Aids (ARPA).
- A.820(19) Performance Standards for Navigational Radar Equipment for High-Speed Craft.
- A.278(VIII) Supplement to Performance Standards for Navigational Radar Equipment.

Annex 2 combines the requirements of all four existing documents into a single comprehensive document, applicable to all ships subject to radar carriage requirements. The revision also takes account of the information currently contained in resolution A.917(22) and SN/Circ.217.

10 These revised Performance Standards consolidate all aspects of radar system performance and include:

.1 addressing the changing needs of users, including reducing the workload by simplifying the operational use of radar, as reflected in user surveys;

.2 recognizing the user's need for higher detection performance, particularly relating to target detection in difficult weather conditions and faster moving targets;

.3 consideration of frequency spectrum and emission requirements of the ITU;

.4 embracing new technology to benefit the user and enhance safety at sea;

.5 combining and harmonizing current radar and plotting IMO Standards, including IMO guidelines for the use and display of AIS;

.6 embracing the new proposed IMO Performance Standards for the "Presentation and Display of Navigational Related Information" covering harmonization of display and presentation aspects;

.7 enhancing equipment to be compatible with System Integration;

.8 correlation with chart data for position monitoring; and

.9 correlation of radar and AIS data for improved target tracking and collision avoidance.

11 These revised Performance Standards apply to stand-alone radars, to radars combining the display of AIS and charts, and to radars being part of an integrated system.

Significant Areas of Revision

12 These revised Performance Standards include improved requirements for the performance of radar equipment in terms of range of first detection and detection of small targets in clutter-free conditions. The complexity of detection in clutter is such that the CG considered it appropriate to recommend further research into feasible means of describing a benchmark for performance in clutter, and specifically range of first detection in defined clutter environments. These clutter environments were proposed as Sea States 2 and 5, as rainfall of 4mm/hr and 16mm/hr, and as a combination of these. The definition of detection in clutter and an acceptable means of testing range of first detection in clutter are considered fundamental to the production of a meaningful testing standard and IEC should be tasked accordingly.

13 It is considered that the determination of risk of collision can best be achieved by automatic target tracking (rather than manual plotting) and the revised Performance Standards therefore make automatic Target Tracking a mandatory requirement for all radars.

14 AIS equipment is now a mandatory carriage requirement for SOLAS vessels. The most logical display for indicating graphically AIS information from other ships is the radar display. Radar tracking information can also be significantly enhanced by incorporating information available from AIS. The display of AIS reported targets and association of these reported targets with radar tracked targets is therefore included in the revised Performance Standards.

15 The display of selected System Electronic Navigational Chart (SENC) and other vector chart information, including a layering facility on the radar display, is seen as highly beneficial to the OOW. This facilitates a better awareness of the navigational situation and provides a simple method of checking the integrity of Electronic Position Fixing System (EPFS) data against positional information available from radar. The revised Performance Standards again include this as an optional facility.

16 RACONs provide a valuable aid to the mariner, but the requirement to trigger current generation RACONs and SARTs forces the continued use of 60 year old pulsed radar principles and thereby prevents beneficial developments. Whilst compatibility with SARTs (and hence current RACONs) at X band must remain until a replacement beacon is mandated by IMO, the mandatory requirement to operate with RACONs at S band has been removed from the revised Performance Standards, thus allowing innovative design of radar operating in this band.

17 Display modes have been simplified and the revision includes the requirement to display selectable relative or true target trails and to maintain the display of target trails and/or past positions when range scales are changed and own ship position is reset.

18 The revision also includes the concept of using a consistent common reference point (CCRP) for all radar measurements.

Ducting and Ducting Forecast

Effects of atmospheric ducting on radar propagation

19 In normal atmospheric conditions the temperature and ability of the air to contain moisture, decreases with height. Occasionally, a condition referred to as 'inversion' occurs when a layer of warm air is "trapped" under a cooler layer, so that the temperature actually (initially) increases with altitude. Also, the moisture content of the atmosphere over large water masses is often greater than normal (moisture lapse) and as a consequence, the reduction in moisture content with altitude will be more rapid. Either, or both of the above can cause significant changes to the refraction index (super refraction) of the lower atmosphere (typically up to 300 metres) and this can result in greater 'bending' of radar waves through this 'corridor' or **duct.** The moisture lapse often generates a "surface duct" also known as an **evaporation duct**. One result of these phenomena can be greatly increased radar range. It should be stressed that ducting is not always beneficial to radar performance and in certain conditions (**sub-refraction**), the radar range can be drastically reduced. Investigations of several maritime collisions have identified atmospheric degradation of radar performance as a significant factor in the incidents. In the worst conditions, radar can be rendered almost "blind" and the mariner at present has no forecast warning of these conditions.

Meteorological Forecast of Ducting

20 It is considered of benefit to the mariner that, when meteorological conditions exist which significantly alter normal radar performance; this information should be included in the marine forecast.

Report from the Correspondence Group

21 The report from the work in the IMO Correspondence Group on shipborne radar equipment, where more detailed information can be found, is attached as annex 1.

Action requested of the Sub-Committee

22 The Sub-Committee is invited to:

.1 consider the report from the Correspondence Group;

.2 consider the proposed draft revised Performance Standards for radar in annex 2 and, recognizing the close relationship between these standards and the draft Performance Standards for the Display of Navigation related information and decide accordingly;

.3 consider revisions to SOLAS chapter V, Regulation 19 at the next routine opportunity to reflect the requirement for automatic Target Tracking on all radar equipment and the mandatory interfacing of AIS equipment to the radar;

.4 consider revoking SN/Circ.217 (replaced by both the Radar and the Presentation Standards);

.5 consider the problems with spectrum restrictions or sharing spectrum with other users and strongly address the ITU in order to secure adequate bandwidth and give the shipborne radar priority if the spectrum is shared with other services;

.6 consider the provision of ducting forecasts and encourage the World Meteorological Organisation to provide appropriate forecasts;

.7 consider the need for installation guidelines for shipborne radar and the addition of this item to the work programme for the NAV sub-committee;

.8 note, that in any future revision of Performance Standards for Navigation Systems or Equipment or Integrated Systems, or in development of new task based Performance Standards, it might be necessary to open this and other relevant standards, in order to clarify and to maintain compatibility across standards;

.9 make the STW Sub-Committee aware of these revised Performance Standards so that they may review the content of the STCW Convention and relevant model courses;

.10 make the COMSAR Sub-Committee aware of the restrictions on radar design imposed by the continued use of SARTs; and

.11 inform IALA of the proposed changes to S band radar regarding RACONs.

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ANNEX 1

Report from the Correspondence Group

1 Background

Germany, Norway and the United Kingdom submitted a joint proposal (NAV 49/9) for new amended Performance Standards (PS) for shipborne radar to NAV 49. The Sub-Committee considered the draft PS (NAV 49/9) in Plenary and the Technical Working Group. The document highlighted a number of important areas where further work was required before a final draft revision of PS for radar equipment could be presented to NAV 50. It was considered that mariners should take a very active part in these discussions to develop and confirm the functions and performance required by this vital piece of navigational equipment.

In order to promote active discussion and finalization of the work in 2004, and to facilitate the incorporation of the mariner's views, NAV 49 established a correspondence group (CG) co-ordinated by Norway. The work in the CG was presupposed to be done in close cooperation with the ongoing work in International Electrotechnical Commission (IEC) TC 80 WG 1 to develop revised testing standards for radars.

The Sub-Committee agreed that issues to be addressed by this group should include:

1. Confirmation of the Radar Cross Section (RCS) of relevant targets.
2. Consideration of the harmonization of design and certain important operational controls.
3. Further studies of the relative virtues of sea and ground stabilization of the radar display and display modes.
4. The use made of RACONs operating at S-band.
5. Assessment of costs associated with enhanced performance.

2 Meetings of the Correspondence Group

The Correspondence Group had four joint meetings with IEC TC 80 WG1:

- Hamburg, London, Hamburg, Oslo and several additional work shops were attended by Mariners and different radar experts.
- Participants at the meetings represented the following countries: Japan, Sweden, Poland, the United States, the United Kingdom, Denmark, Germany and Norway.

3 Input information to the Correspondence Group

(1) Administrations and organizations were invited to provide inputs on NAV 49/9 to the CG. The CG received initial input from: Japan, the United Kingdom, Germany and Norway. The input was based on user surveys and radar and navigation work shops and discussion in different nautical and navigational forums. This input was incorporated in the revised PS. The input from mariners is mainly based on a questionnaire extracted from unsolved questions and text in square brackets in the draft PS presented to the Sub-Committee (NAV 49/9).

Several Radar Work Shops and User Consultations with active sea officers have been held.

(2) IEC has provided technical input to optimize detection requirements. IEC has also provided technical guidance to make the PS reflect recent technical development. The result of the ongoing work in IEC is also included in the revised PS.

(3) A preliminary report was sent to all Administrations present at NAV 49, in December 2003. The report informed about the progress made in the CG, and requested comments and input for the current draft version at the time. The current draft version of the revised PS was presented at NMD's website from December 2003.

(4) In January/February 2004, the CG received additional input from:

- Japan, Sweden, Poland, the United States, the United Kingdom, Denmark, Germany and Norway.

(5) Finalization of the draft PS took place at a meeting of the CG in Oslo from 1-4 March 2004, before final submission to NAV 50.

4 Discussions on relevant and controversial performance issues

4.1 Radar Cross Section (RCS) of relevant targets

Radar Cross Section (RCS), otherwise referred to as Radar or Effective Echoing Area (R/EEA) and measured in square metres (m^2) is the accepted measurement of the size of targets as seen by radar. The RCS of a target is related to its physical size, its shape, the materials from which it is constructed and the aspect from which it is viewed. RCS also varies with the frequency band in use by the radar.

RCS is a key value in the radar range equation which provides a theoretical indication of the range at which a target may be detected (this range varying with RCS^2). A good estimate of the RCS of given targets is therefore essential before required detection ranges can be specified and equipment tested. For the purposes of this revision, the following typical RCS values, averaged over 360° in azimuth where appropriate, have been used:

TABLE 1
Radar Cross Sections (RCS)

	Typical RCS (m^2)		
Target description	Height (m)	X Band	S Band
Shorelines	Rising to 60	50,000	50,000
Shorelines	Rising to 6	5,000	5,000
Shorelines	Rising to 3	2,500	2,500
SOLAS vessel (>5000gt)	10	50,000	30,000
SOLAS vessel (>500 gt)	5	1,800	1,000
Small vessel with Radar Reflector meeting IMO Performance Standards	4	7.5	0.5
Navigation buoy with corner reflector	3.5	10	1.0
Navigation buoy	3.5	5	0.5
Small vessel of length 10m (without radar reflector)	2	2.5	1.4

It should be remembered that:

a. the RCS of a vessel will vary considerably between that seen from a broadside aspect and that seen from the bow/stern aspect;
b. the total RCS may be made up from a number of contributing reflecting surfaces and the complex interaction of the signals reflected from each may result in unexpected enhancement/degradation of the overall reflected signal as seen by radar; and
c. the apparent centre of the RCS (radar centroid - the centre of the target as seen by radar) may not coincide with the lateral and vertical centre of the target as seen visually.

4.2 Radar Detection of relevant targets

Much work has been done, particularly in relation to the revised Radar Reflector Performance Standard (NAV 49/7), to determine the RCS of small targets and their detectability by radar.

It is fundamental to this revision of the radar performance standard that the mariners' requirement for maximum range at first detection, especially of small targets, is addressed whilst recognizing the physical constraints on radar. Data produced from radar performance modelling tools, radar range tests and practical trials have all been considered in reaching the figures proposed. These are intended to be stretching but achievable without the need for new radar technology. This data has been reflected in Table 2.

TABLE 2
Minimum range at first detection in clutter-free conditions

Target Description	Target Feature	Detection Range in NM	
Target description	Height above sea level in metres	X Band NM	S Band NM
Shorelines	Rising to 60	20	20
Shorelines	Rising to 6	8	8
Shorelines	Rising to 3	6	6
SOLAS vessel (>5000gt)	10	11	11
SOLAS vessel (>500 gt)	5.0	8	8
Small vessel with Radar Reflector meeting IMO Performance Standards	4.0	5.0	3.7
Navigation buoy with corner reflector	3.5	4.9	3.6
Typical Navigation buoy	3.5	4.6	3.0
Small vessel of length 10m with no radar reflector	2.0	3.4	3.0

The ranges in table 2 represent those which should be achieved in calm conditions with no clutter and without evaporation ducting effects included and with all radar settings optimized.

TABLE 3
Comparison of Performance Requirements

Minimum detection ranges in clutter free conditions (X/S)

	Target Height (m)	RCS sqm X / S	60936-1 Current Standard	NAV 49 Draft values in [ ]	NAV 50 Draft Proposed	Comment
Target						
Shorelines	60	50,000	**20 / 20**	**16 / ---**	**20 / 20**	
Shorelines	6	5,000	**7 / 7**	**8 / ---**	**8 / 8**	
Shorelines	3	2,500	**---**	**---**	**6 /6**	
SOLAS >5000gt	10	50,000	**7 / 7**	**---**	**11 / 11**	
SOLAS >500gt	5.0	1800 / 1000	**---**	**5.5 / ---**	**8 / 8**	
Small vessel, + IMO Reflector	4.0	7.5 / 0.5	**---**		**5.0 / 3.7**	
Navigation buoy 1	3.5	10 / 1.0	**2 / 2**		**4.9 / 3.6**	
Navigation buoy 2	3.5	5 / 0.5	**---**	**3.5 / ---**	**4.6 / 3.0**	**Lower RCS, exceeds 936-1**
Small craft of <10m	3.0	10 / 1.0	**---**	**4.5 / ---**	**---**	**RCS high wrt NAV50 SV**
Small vessel of 10m undefined	Undefined height	Undefined RCS	**3 / 3**	**---**	**---**	**SV must be >>10sqm**
Small vessel, no Reflector	2.0	2.5 / 1.4	**---**	**---**	**3.4 / 3.0**	
			NM	**NM**	**NM**	

This table determines the differences in detection ranges in the current Radar Performance Standards, the draft version presented to NAV 49 and the new draft radar performance standards set out in Annex II.

Notes:

1. The small vessel defined in IEC60936-1 was undefined regarding target height and RCS. The range performance was given as 3NM and did not differentiate between X and S band. The radar reflector of 10sqm was required to be seen at 2NM and was mainly used for testing minimum range and target discrimination. We could assume that the small boat had a higher RCS than the proposed 2.5sqm.
2. The current IMO and IEC60936-1 performance figures were based on those defined in 1972 and these were not reviewed in the 1988 /1999 revisions.
3. Where there was no equivalent target, --- has been shown in the table.
4. The NAV50 submission includes two navigation buoys for comparison purposes
5. It appears that IEC936 and subsequently the IEC60936-1 version, were probably optimistic in the detection of the small boat detection range, but could have been based on observations of unknown targets in terms of RCS.

4.3 Harmonization of important operational radar controls

Feedback from active Mariners, particularly from pilots, indicates that common operation of controls is a strong requirement. It has been established that different user interfaces for each type of radar equipment, represents a problem by increasing the workload for the mariner, particularly for those users with frequent change of ships.

The input was based on several user surveys, radar and navigation work shops and discussion in different nautical and navigational forums. We therefore recommend a harmonized user interface and that a set of primary controls are identified. The primary controls being considered for a common user interface and as far as practical, are harmonized by these revised IMO Performance Standards.

4.4 The presentation modes

To simplify radar operation (which is a clear user requirement), it is proposed that the different presentation modes are reduced in number and specified for their respective and improved use.

4.4.1 Position monitoring: True motion picture of stationary targets

For position monitoring, the true motion display with fixed targets being stationary on the screen and showing no trails is needed. For this application there is no requirement for a moving "landscape". ECDIS experience, (where there is no discussion about relative or true motion display), has shown that own ship moving at her own course and speed in near-real time in a true motion display is the most realistic display for position monitoring. The re-set of the radar origin can be arranged such that the mariner may select an appropriate look-ahead, or an appropriate time interval for re-setting. Should a mariner wish to retain the relative radar picture presentation, this mode may be provided by re-setting the radar picture at least after every rotation of the antenna (known as "Centre display" or "True motion / Fixed Origin").

4.4.2 Collision avoidance: Trails for target motion

For collision avoidance, the users require the motion of target vessels to be displayed without the need of acquisition/activation. This requirement can be fulfilled by target trails which contain all information needed for collision avoidance:

- True trails give a good overview on all targets motion and maneuvers;
- Relative trails give a clear indication of collision risk ("steady bearing").

The mariner should have the possibility, within a true motion picture, to select true or relative trails. Moreover, trails assist in detecting weak reflecting targets.

The processing (and display) of relative trails in a true motion radar display is technically not easy and problems arise in the cases of changing range scale, re-setting the origin and changing between true and relative trails. In these cases, the trails have to be reconstructed which may take some minutes. To fill the gap, "past-positions" derived from tracked target data may be provided instead. This procedure may avoid the fact that mariners hesitate to change range scales because they are afraid to loose the trails at all.

4.4.3 The stabilization mode

In essence, the value for course through water (CTW) and the sea-stabilized motion display are no longer needed because:

- the aspect problem (difference of headings) is solved for all SOLAS vessels due to the availability of AIS transmitted heading;
- the CTW-based aspect, in principle, may not in reality be determined, but only guessed (assuming e.g. identical effect of wind and current on own ship and target vessel) and is generally not correct; and
- AIS data (COG, SOG) and radar data (COG, SOG or CTW, STW) have to be associated.

Therefore, ground-stabilized motion radar display and the use of the correct aspect (difference of headings) are sufficient and all ambiguities will disappear. Even the existence of occasional "No-heading targets" (targets the heading of which is not known) will not diminish the superiority of ground-stabilization. Traditional sea stabilization may be used as an option or a fallback solution.

4.4.4 Orientation of the radar picture

North-up and course-up orientation modes are sufficient. Head-up orientation which suffers from:

- unstable display of the target of the bearing; and
- the risk of suppressing the display of targets due to correlation-based anti-clutter procedures,

is inferior to course-up and can be selected in true motion fixed origin mode and as a fall-back mode.

4.4.5 Simplifications of presentation modes

Based on the arguments discussed above, the presentation modes:

- relative north-up
- true motion/fixed origin (also called "centre display"),

do not need to be provided in normal operation mode, though they should remain available.

4.5 Display of charts on radar

Integrating an electronic chart with radar, or at least enabling the user to overlay some selected SENC and other vector chart information, provides a system which can be used for both position monitoring and collision avoidance. The mariner receives the following relevant information on a single screen: own ship's position, all other vessels and uncharted objects in the sea area and all selected charted objects and obstacles.

Besides other benefits, the radar chart data overlay and object correlation/identification are of particular value:

- for position fixing because, the overlay provides a permanent radar-fix without requiring action from the mariner; and
- for real-time position monitoring by checking the ship's Electronic Position Fixing System (EPFS), e.g. GPS.

As long as radar echo paints and corresponding chart objects match, own ship's EPFS (GPS) is reliable. However, if the radar echoes of fixed objects do not match the ENC objects, but are not in alignment, there is obviously an error in the EPFS and potentially in the geodetic datum. Moreover, if the radar picture and the chart data are out of rotational alignment, there is obviously a heading reference error or a gyro error.

Thus, radar may serve as a second and independent position fixing system, i.e. the display of chart objects on the radar picture is a potential position-fixing system back-up. Therefore the chart overlay on radar should be encouraged. In particular, when appropriate stationary references are available (e.g. light houses), it is not as necessary for the ship to carry other EPFS equipment such as LORAN-C as alternative. The chart radar overlay is particularly safety-relevant in automatic track control mode (TC) where – due to the task of the controller - the current own ship GPS position is always displayed on the planned track, independent of any possible GPS error. This might mislead the mariner to over-rely on the system. A radar overlay showing discrepancies between radar and chart objects will immediately indicate the danger.

Although a temporary display of raster chart data on the radar would also allow temporary position monitoring, this is not proposed because:

- within a few years ENC coverage will be increased; therefore there should be no encouragement for using raster chart data;
- the scaling and orientation of raster chart data on a radar is a problem; and
- overload of information may cause dangerous situations as raster charts are not layered.

4.6 Screen sizes and concerns over availability of suitable products in future

The Radar Performance Standards recognize the need for three screen sizes to address the diversity of vessels covered by the SOLAS carriage requirements. Each screen size is the minimum recommended for the class of vessel, which should be provided with the largest screen size possible within the confines of the navigational bridge. The increase in the presentation content of the radar display to include AIS and layers of vector chart information, in particular SENC, demands a greater screen area to display information with clarity. New flat screen display technology has provided the benefits of better resolution, high brightness, reduced physical depth and immunity from magnetic discoloration.

The 180 mm radar diameter has been retained for smaller vessels, where considerations of space and cost are at a premium. The 250 mm radar diameter is the minimum recommended for medium vessels, high-speed craft and multiple layers of chart information, offering a larger screen area to accommodate the increase in information. The 320 mm radar diameter is a further

enhancement, capable of presenting yet more information with the clarity expected by the mariner to achieve safe and unambiguous navigation.

Whereas the 180 mm and 250 mm screen sizes are readily available and are multi-sourced, the 320 mm display is currently only provided by a single source and availability should therefore be considered at risk. Manufacturers of flat screens have not declared their intentions for large screen availability in the medium and longer term, particularly for the required resolution and aspect ratio. The drive for bigger screens is dictated by the needs of the mass commercial market and while the marine radar benefits from the scale of volume, it is constrained by the media requirements. Whilst recognizing the mariner need for a large display, IMO should be aware of a possible difficulty for the continuity of supply of the larger screen format. That said, in the interests of safety, IMO should advocate the largest display possible for the bridge of a ship.

4.7 Automatic Target Tracking

SOLAS Chapter V Reg. 19.2.3.3 requires Electronic Plotting Aid (EPA) for all ships between 300 and 500 gross tonnage (gt), and for all passenger ships up to 300 gt.

EPA does not offer the Officer of the Watch (OOW) the information needed in determination of risk of collision. This task can best be done by automatic Target Tracking. These requirements are based on user experience. Therefore the draft revised PS requires automatic Target Tracking, similar to today's ATA and ARPA, for all ships. This enhancement offers a function which will increase safety and simplifies training. The CG recommends that the requirement of Target Tracking to all ships is incorporated in SOLAS Chapter V Regulation 19 at the next opportunity for routine revision of this chapter.

4.8 Operation with RACONs and SARTs

Feedback from active Mariners indicates that RACONs operating in both radar bands continue to be used and valued as they provide identification of key aids to navigation using a mechanism independent of GNSS. It must be remembered, however, that RACONs (and latterly SARTs) were developed to work with pulsed radars using traditional techniques. Continuing the requirement for radars to trigger RACONs and SARTs using current techniques imposes limitations on the evolution of radar transmitter techniques. These limitations, when coupled with developing ITU requirements to restrict unwanted emissions and promote band sharing, may well result in increased costs and complexity of future equipment. Further, they can be expected to significantly restrict manufacturers' possibilities to improve radar detection performance, especially for small targets and in clutter conditions.

Whilst at X band, compatibility with SARTs (and consequently RACONs) must remain until a replacement SAR transponder/beacon is mandated by IMO, it is considered that the requirement to operate with RACONs at S band should be removed from the mandatory performance requirements. This would allow innovative design of radar operating in this band and open the way for developments which could result in improved radar performance and/or more economic equipment. The mariners' perceived needs for an independent identification mechanism will continue to be fulfilled by X band RACONs and perhaps by the evolution of the S band RACON to match radar developments in due course.

It should be noted that removing this functional requirement of the S band radar will in no way require existing S band RACONs to be removed, inhibited or modified. Signals from these beacons will continue to be visible on current radars and new radars in the near future and indeed new radars intended for customers specifically requiring this capability as long as they are transmitting.

4.9 Consistent Common Reference Point (CCRP)

CCRP is a location on own ship, to which all horizontal measurements such as target range, bearing, relative course, relative speed, closest point of approach (CPA) or time to closest point of approach (TCPA) are referenced, typically the conning position of the bridge.

This reference point is a new common point which all range and bearing measurements will be taken from, this to have one consistent point. The definition has been agreed together with the IMO Presentation Correspondence Group and IMO Correspondence Group for INS.

5 Assessment of costs

While recognizing the projected reduction in the cost of electronic components, these performance standards will result in an increase in equipment cost. Possible cost savings have been considered in all respects and some of the requirements within the performance standard are a compromise between benefits and cost. However taking this into account, initial estimates are indicating 20% to 50% increase in equipment cost to meet the proposed IMO requirements, relative to the current IMO minimum requirement. The actual incremental cost will vary according to the current capability of each equipment. The cost drivers are:

- Improved target detection – may be achieved by using higher power transmitters, improved receiver noise figures, extension of the receiver system dynamic range, enhanced antenna design, more robust gearboxes with electronic control and larger upmast transceiver housing with uprated cooling.
- Enhanced target detection in clutter – improved processing and antenna techniques to detect small targets within in the clutter field, while maintaining a ‘noise free’ presentation.
- Display of AIS information – Increased processing power and memory to address the filtering and handling of the potential large quantity of reported AIS targets.
- Capability of displaying chart information – Higher processing capability, license costs and conformance to SENC and other chart data requirements.
- Improved display resolution – adoption of flat screen technology to achieve the better resolution required for the display of smaller symbols, AIS and chart information, upgraded to meet the marine environment and for operating in the ambient light conditions likely to be encountered on a bridge.
- Range scaled target trails / past positions – increased memory and processor overhead;
- Automatic target tracking – increases the minimum processing and memory requirement for target tracking, particularly with higher relative target velocities (possibly demanding higher antenna rotation rates).

- Harmonized controls – possible hardware costs.
- Investment / Approval / Production costs – Increased investment and development times, higher type approval costs and increased production testing.

6 Consequences of future spectrum restrictions

The pressure to use the radar spectrum more efficiently has grown as more and more new radio applications are developed. One of the solutions which have come up by ITU-R, is to share the radar spectrum with shore based equipment, another is to limit the bandwidth available to shipborne radar. The CG for radar finds that sufficient frequency bandwidth should be secured for navigation purposes and that sharing is very difficult and not at all desirable. If sharing of radio spectrum notwithstanding will be the future solution, shipborne radar should be given priority, assuming that this can be done without jeopardising safe navigation in coastal waters, where radar is most important. Sharing of radio spectrum must take adequate consideration to the importance of radar to be free of any interference in coastal navigation. To process such sharing the CG strongly recommend that the shipborne radar is given priority above other applications.

7 Co-ordination with other groups

The IMO Presentation Correspondence Group supported by IEC WG13 and the IMO Radar Correspondence Group supported by IEC WG1 have recognized the importance of compatibility between the Presentation Standards and these Radar Standards. Close liaison has ensured the co-ordination of requirements, accepting that in some instances, there will be some duplication that proved necessary for cross referencing the documents. The two standards are inter-dependent and their synchronised enforcement, following the publication of the Test Standards, is critical for training and for the future approval of equipment.

8 The relation to SOLAS chapter V

Certain requirements regarding the capability of radar equipment performance are contained within Chapter V of SOLAS. Minor changes to these may need to be considered at the next opportunity for routine revision of this chapter.

9 Future structure of performance standards

The format of this performance standard which combines requirements for sensors, processing, function and presentation may inhibit the development of these items as separate standards in the future. The CG is aware that future development will affect this standard and other relevant navigational standards; this may include moving of sections or parts of this PS to new or amended standards. These standards will need to be kept up to date and any revision process harmonized. This task is beyond the mandate of the CG who considers that it would be useful to build up a new set of performance standards with requirements relating to:

- Sensors
- Functions
- Processing
- Presentation

This would encourage the integration of different sensors, functions and displays on one system and to provide adequate information for the required navigational task at hand. Also, it would facilitate the possibility of building a minimum stand-alone system as we know it today. This does not imply that the technical and operational aspects of the radar standard will need to be changed.

10 Final Comments

The Norwegian Maritime Administration will heartily thank all Administrations, Radar Experts and especially all Mariners who have taken interest in the revision of the radar standard. Without all the enthusiastic involvement from individuals, organizations and companies the task could not have been accomplished. Hopefully the maritime industry can benefit from this work in many years to come, in safer navigation and relief of the work load on the officer of the watch.

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ANNEX 2

INDEX

Draft Radar Performance Standards for Ship-Borne Radar Equipment

1 SCOPE OF EQUIPMENT

2 APPLICATION OF THESE STANDARDS

3 REFERENCES

4 DEFINITIONS

5 OPERATIONAL REQUIREMENTS FOR THE RADAR SYSTEM

6 ERGONOMIC CRITERIA

7 DESIGN AND INSTALLATION

8 INTERFACING

9 BACKUP AND FALLBACK ARRANGEMENTS

1 SCOPE OF EQUIPMENT

The radar equipment should assist in safe navigation and in avoiding collision by providing an indication, in relation to own ship, of the position of other surface craft, obstructions and hazards, navigation objects and shorelines.

For this purpose, radar should provide the integration and display of radar video, target tracking information, positional data derived from ownship's position (EPFS) and geo referenced data. The integration and display of AIS information should be provided to complement radar. The capability of displaying selected parts of System Electronic Navigation Chart (SENC) and other vector chart information may be provided to aid navigation and for position monitoring.

The radar, combined with other sensor or reported information (e.g. AIS), should improve the safety of navigation by assisting in the efficient navigation of ships and protection of the environment by satisfying the following functional requirements:

- in coastal navigation and harbour approaches by giving a clear indication of land and other fixed hazards;
- as a means to provide an enhanced traffic image and improved situation awareness;
- in a ship-to-ship mode for aiding collision avoidance of both detected and reported hazards;
- in the detection of small floating and fixed hazards for collision avoidance and the safety of own ship.

2 APPLICATION OF THESE STANDARDS

These standards supersede all previous radar and plotting standards.

These standards apply to all ship-borne navigational radars used in any configuration on the navigation bridge.

These Performance Standards should apply to all radar installations mandated by SOLAS independent of the:

- type of ship
- frequency band in use
- type of display
- providing that no special requirements are specified in Table 1 and that additional requirements for specific classes of vessel (in accordance with SOLAS Chapter V and X) are met.

The radar installation, in addition to meeting the general requirements as set out in resolution A.694(17), should comply with the following performance standards.

Close interaction between different navigation equipment and systems, makes it essential to consider this standards in correlation with other relevant IMO standards.

TABLE 1

Defines the differences in the performance requirements for various sizes / categories of ship /craft falling under SOLAS

Size of ship / craft	<500gt	500gt to <10000gt and HSC<10000gt	All ships / craft ≥10000gt
Minimum effective screen diameter	180mm	250mm	320mm
Minimum screen area	195x195mm	270x270mm	340x340mm
Auto acquisition of targets	-	-	Yes
Minimum ***acquired*** radar target capacity	20	30	40
Minimum ***activated*** AIS target capacity	20	30	40
Minimum ***sleeping*** AIS target capacity	100	150	200
Trial Manoeuvre	-	-	Yes

3 REFERENCES

References are in Appendix 1.

4 DEFINITIONS

Definitions are in Appendix 2.

5 OPERATIONAL REQUIREMENTS FOR THE RADAR SYSTEM

The design and performance of the radar should be based on user requirements and up-to-date navigational technology. It should provide effective target detection within the safety-relevant environment surrounding own ship and should permit fast and easy situation evaluation.[1]

5.1 Frequency

5.1.1 Frequency Spectrum

The radar should transmit within the confines of the ITU allocated bands for maritime radar and meet the requirements of the radio regulations and applicable ITU-R recommendations.

[1] Refer to MSC/Circ 878 , the Human Element Analysing Process (HEAP)

5.1.2 Radar Sensor Requirements

Radar systems of both X and S band are covered in these performance standards:

- X band (9.2- 9.5 GHz) for high discrimination, good sensitivity and tracking performance.
- S band (2.9–3.1 GHz) to ensure that target detection and tracking capabilities are maintained in varying and adverse conditions of fog, rain and sea clutter.

The frequency band in use should be indicated.

5.2 Radar Range and Bearing Accuracy

The radar system range and bearing accuracy requirements should be:

Range - within 30m or 1% of the screen range scale in use, whichever is greater;

Bearing - within 1°.

5.3 Detection Performance and Anti-clutter Functions

All available means for the detection of targets should be made available to user.

5.3.1 Detection

5.3.1.1 Detection in Clear Conditions

In the absence of clutter, for long range target and shoreline detection, the requirement for the radar system is based on normal propagation conditions, in the absence of sea clutter, precipitation and evaporation duct, with an antenna height of 15m above sea level.

Based on an indication of the target in at least 8 out of 10 scans and a false alarm rate of 10^{-4}, the requirement contained in Table 2 should be met as specified for S and X band equipment.

The detection performance should be achieved using the smallest antenna that is available with the radar system.

Recognizing the high relative speeds possible between own ship and target, the equipment should be specified and approved as being suitable for classes of ship having normal (<30kn) or high (>30kn) own ship speeds (100kn and 140kn relative speeds respectively).

TABLE 2

Minimum detection ranges in clutter-free conditions

Target Description	Target Feature	Detection Range in NM[6]	
Target description[5]	Height above sea level in metres	X Band NM	S Band NM
Shorelines	Rising to 60	20	20
Shorelines	Rising to 6	8	8
Shorelines	Rising to 3	6	6
SOLAS vessel (>5000gt)	10	11	11
SOLAS vessel (>500 gt)	5.0	8	8
Small vessel with Radar Reflector meeting IMO Performance Standards[1]	4.0	5.0	3.7
Navigation buoy with corner reflector[2]	3.5	4.9	3.6
Typical Navigation buoy[3]	3.5	4.6	3.0
Small vessel of length 10m with no radar reflector[4]	2.0	3.4	3.0

5.3.1.2 Detection at Close Range

The short-range detection of the targets under the conditions specified in table 2 should be compatible with the requirement in paragraph 5.4.

5.3.1.3 Detection in Clutter Conditions

Performance limitations caused by typical precipitation and sea clutter conditions will result in a reduction of target detection capabilities relative to those defined in 5.3.1.1 and table 2.

5.3.1.3.1 The radar equipment should be designed to provide the optimum and most consistent detection performance, restricted only by the physical boundaries of propagation.

5.3.1.3.2 The radar system should provide the means to enhance the visibility of targets in adverse clutter conditions at close range.

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1 IMO revised performance standards for radar reflectors – RCS 7.5m^2 for X band, 0.5m^2 for S band.

2 The corner reflector (used for measurement), is taken as 10m^2 for X band and 1.0m^2 for S band.

3 The typical navigation buoy is taken as 5.0m^2 for X band and 0.5m^2 for S band.

4 RCS for 10m small vessel taken as 2.5m^2 for X band and 0.25m^2 for S band.

5 Reflectors are taken as point targets, vessels as complex targets and shorelines as distributed targets (typical values for a rocky shoreline, but are dependent on profile).

6 Detection ranges experienced in practice will be affected by various factors, including atmospheric conditions (e.g. evaporation duct), target speed and aspect, target material and target structure. These and other factors may either enhance or degrade the detection ranges stated. At ranges between the first detection and ownship, the radar return may be reduced or enhanced by signal multi-path, which depend on factors such as antenna / target centroid height, target structure, sea state and radar frequency band.

5.3.1.3.3 Degradation of detection performance (related to the figures in table 2) at various ranges and target speeds under the following conditions, should be clearly stated in the user manual:

- light rain (4 mm per hour) and heavy rain (16 mm per hour)
- sea state 2 and sea state 5
- and a combination of these

5.3.1.3.4 The determination of performance in clutter and specifically, range of first detection, as defined in the clutter environment in .3, should be tested and assessed against a benchmark target, as specified in the Test Standard.

5.3.1.3.5 Degradation in performance due to a long transmission line, antenna height or any other factors should be clearly stated in the user manual.

5.3.2 Gain and Anti-Clutter Functions

5.3.2.1 Means should be provided, as far as is possible, for the adequate reduction of unwanted echoes, including sea clutter, rain and other forms of precipitation, clouds, sandstorms and interference from other radar.

5.3.2.2 A gain control function should be provided to set the system gain or signal threshold level.

5.3.2.3 Effective manual and automatic anti-clutter functions should be provided.

5.3.2.4 A combination of automatic and manual anti-clutter functions is permitted.

5.3.2.5 There should be a clear and permanent indication of the status and level for gain and all anti-clutter control functions.

5.3.3 Signal Processing

5.3.3.1 Means should be available to enhance target visibility on the display screen.

5.3.3.2 The effective picture update period should be adequate, with minimum latency to ensure that the target detection requirements are met.

5.3.3.3 The picture should be updated in a smooth and continuous manner.

5.3.3.4 The equipment manual should explain the basic concept, features and limitations of any signal processing.

5.3.4 Operation with SARTs and Radar Beacons

5.3.4.1 The X band radar system should be capable of detecting radar beacons in the relevant band.

5.3.4.2 The X band radar system should be capable of detecting SARTs.

5.3.4.3 It should be possible to switch off those signal processing functions, including polarization modes, which might prevent an X band radar beacon or SARTs from being detected and displayed. The status should be indicated.

5.4 Minimum Range

5.4.1 With own vessel at zero speed, an antenna height of 15m above the sea and in calm conditions, the navigational buoy in Table 2 should be detected at a minimum horizontal range of 40 m from the antenna position and up to a range of 1nm, without changing the setting of control functions other than the range scale selector.

5.4.2 Compensation for any range error should be automatically applied for each selected antenna.

5.5 Discrimination

Range and bearing discrimination should be measured in calm conditions, on a range scale of 1.5 nm or less and at between 50% and 100% of the range scale selected:

5.5.1 Range
The radar system should be capable of displaying two point targets on the same bearing, separated by 40 m in range, as two distinct objects.

5.5.2 Bearing
Radar systems should be capable of displaying two point targets at the same range, separated by 2.5° in bearing, as two distinct objects.

5.6 Roll and Pitch

The target detection performance of the equipment should not be substantially impaired when own vessel is rolling or pitching up to +/-10°.

5.7 Radar Performance Optimization and Tuning

5.7.1 Means should be available to ensure that the radar system is operating at the best performance. Where applicable to the radar technology, manual tuning should be provided and additionally, automatic tuning may be provided.

5.7.2 An indication should be provided, in the absence of targets, to ensure that the system is operating at the optimum performance.

5.7.3 Means should be available (automatically or by manual operation) and while the equipment is operational, to determine a significant drop in system performance relative to a calibrated standard established at the time of installation.

5.8 Radar Availability

The radar equipment should be fully operational (RUN status) within 4 minutes after switch ON from cold. A STANDBY condition should be provided, in which there is no operational radar transmission. The radar should be fully operational within 5 seconds from the standby condition.

5.9 Radar Measurements – Consistent Common Reference Point (CCRP)

5.9.1 Measurements from ownship (e.g. range rings, target range and bearing, cursor, tracking data) should be made with respect to the ship's consistent common reference point (e.g. conning position). Facilities should be provided to compensate for the offset between antenna position and the ship's consistent common reference point on installation. Where multiple antennas are installed, there should be provision for applying different position offsets for each antenna in the radar system. The offsets should be applied automatically when any radar sensor is selected.

5.9.2 Ownships scaled outline should be available on appropriate range scales. The consistent common reference point and the position of the selected radar antenna should be indicated on this graphic.

5.9.3 When the picture is centred, the position of the Consistent Common Reference Point should be at the centre of the bearing scale. The off-centre limits should apply to the position of the selected antenna.

5.9.4 Range measurements should be in nautical miles (NM). In addition, facilities for metric measurements may be provided on lower range scales. All indicated values for range measurement should be unambiguous.

5.9.5 Radar targets should be displayed on a linear range scale and without a range index delay.

5.10 Display Range Scales

5.10.1 Range scales of 0.25, 0.5, 0.75, 1.5, 3, 6, 12 and 24nm should be provided. Additional range scales are permitted outside the mandatory set. Low range metric range scales may be offered in addition to the mandatory set.

5.10.2 The range scale selected should be permanently indicated.

5.11 Fixed Range Rings

5.11.1 An appropriate number of equally spaced range rings should be provided for the range scale selected. When displayed, the range separation of the range rings should be indicated.

5.11.2 The system accuracy of fixed range rings should be within 1% of the maximum range of the range scale in use or 30m, whichever is the greater distance.

5.12 Variable Range Markers (VRM)

5.12.1 At least two variable range markers (VRMs) should be provided. Each active VRM should have a numerical readout and have a resolution compatible with the range scale in use.

5.12.2 The VRMs should enable the user to measure the range of an object within the effective radar area with a maximum system error of 1% of the range scale in use or 30m, whichever is the greater distance.

5.13 Bearing Scale

5.13.1 A bearing scale around the periphery of the effective radar area should be provided. The bearing scale should indicate the bearing as seen from the ship's consistent common reference point.

5.13.2 The bearing scale should be outside of the effective radar area. It should be numbered at least every 30° division and have division marks of at least 5° and 10° clearly distinguishable from each other. 1° division marks may be presented where they are clearly distinguishable from each other.

5.14 Heading Line (HL)

5.14.1 A graphic line from the ship's consistent common reference point to the bearing scale should indicate the heading of the ship.

5.14.2 For each radar sensor, electronic means should be provided to align the heading line to better than 0.1°. The heading skew (bearing offset) should be retained and automatically applied when each radar sensor is selected.

5.14.3 Provision should be made to temporarily suppress the heading line. This function may be combined with the suppression of other graphics.

5.15 Electronic Bearing Lines (EBLs)

5.15.1 At least two electronic bearing lines (EBLs) should be provided to measure the bearing of any point object within the effective radar area, with a maximum system error of 1° at the periphery of the display.

5.15.2 The EBLs should be capable of measurement relative to the ships heading and relative to true north. There should be a clear indication of the bearing reference (i.e. true or relative).

5.15.3 It should be possible to move the EBL origin from the ship's consistent common reference point to any point within the radar display area and to reset the EBL to the ship's consistent common reference point by a fast and simple action.

5.15.4 It should be possible to fix the EBL origin or to move the EBL origin at the velocity of ownship.

5.15.5 Means should be provided to ensure that the user is able to position the EBL smoothly in either direction, with an incremental adjustment adequate to maintain the system measurement accuracy requirements.

5.15.6 Each active EBL should have a numerical readout with a resolution adequate to maintain the system measurement accuracy requirements.

5.16 Parallel Index lines (PI)

5.16.1 A minimum of 4 independent parallel index lines, with a means to truncate and switch off individual lines should be provided.

5.16.2 Simple and quick means of setting the bearing and beam range of a parallel index line should be provided. The bearing and beam range of any selected index line should be available on demand.

5.17 Remote Measurement of Range and Bearing

There should be a means to measure the range and bearing of one position on the screen relative to any other position within the effective radar screen area.

5.18 User Cursor

5.18.1 A user cursor should be provided to enable a fast and concise means to designate any position on the display screen.

5.18.2 The cursor position should have a continuous readout to provide the range and bearing, measured from the consistent common reference point, and/or the latitude and longitude of the cursor position.

5.18.3 The cursor should provide the means to select and de-select targets, graphics or objects within the effective radar area. In addition, the cursor may be used to select modes, functions, vary parameters and control menus outside of the effective radar area.

5.18.4 Means should be provided to easily locate the cursor position on the screen.

5.18.5 The accuracy of the range and bearing measurements provided by the cursor should meet the relevant requirements for VRM and EBL.

5.19 Azimuth Stabilization

5.19.1 The heading information should be provided by a gyrocompass or by an equivalent sensor with a performance not inferior to the relevant standards adopted by the organization.

5.19.2 Excluding the limitations of the stabilizing sensor and type of transmission system, the accuracy of azimuth alignment of the radar presentation should be within 0.5° with a rate of turn likely to be experienced with the class of ship.

5.19.3 The heading information should be displayed with a numerical resolution to permit accurate alignment with the ship gyro system.

5.19.4 The heading system should be referenced to the consistent common reference point (CCRP).

5.20 Display Mode of the Radar Picture

5.20.1 A True Motion display mode should be provided. The reset of ownship may be screen position, or time related, or both. Where the reset is selected to occur at least on every scan, this should be equivalent to True Motion with a fixed origin (in practice equivalent to the previous relative motion mode).

5.20.2 North Up and Course Up orientation modes should be provided. Head up may be provided when the display mode is equivalent to True Motion with a fixed origin.

5.20.3 An indication of the motion and orientation mode should be provided.

5.21 Off-Centring

5.21.1 Manual off-centring should be provided to locate the selected antenna position at any point within at least 50% of the radius from the centre of the effective radar area.

5.21.2 On selection of off-centred display, the selected antenna position should be capable of being located to any point on the screen up to 50%, and not more than 75%, of the radius from the centre of the effective radar area. A facility for automatically positioning ownship for the maximum view ahead may be provided.

5.21.3 In True Motion, the selected antenna position should automatically reset up to a 50% radius to a location giving the maximum view along ownship's course. Provision for an early reset of selected antenna position should be provided.

5.22 Ground and Sea Stabilization Modes

5.22.1 Ground and Sea stabilization modes should be provided.

5.22.2 The stabilization mode and stabilization source should be clearly indicated.

5.22.3 The source of ownships' speed should be indicated and provided by a sensor approved in accordance with the requirements of the Organization for the relevant mode.

5.23 Target Trails and Past Positions

5.23.1 Variable length (time) target trails should be provided, with an indication of trail time and mode. It should be possible to select true or relative trails from a reset condition for all true motion display modes.

5.23.2 The trails should be distinguishable from targets.

5.23.3 Either scaled trails or past positions or both, should be maintained and should be available for presentation within 2 scans, following:

- the reduction or increase of one range scale;
- the offset and reset of the radar picture position; and
- a change between true and relative trails.

5.24 Presentation of Target Information

5.24.1 Targets should be presented in accordance with MSC [xx] and with their relevant symbols according to SN/Circ [...].

5.24.2 The target information may be provided by the radar target tracking function and by the reported target information from the Automatic Identification System (AIS).

5.24.3 The operation of the radar tracking function and the processing of reported AIS information is defined in these standards.

5.24.4 The number of targets presented, related to screen size, is defined in Table 1. An alarm should be given when the target capacity of radar tracking or AIS reported target processing / display capability has been exceeded.

5.24.5 As far as practical, the user interface and data format for operating, displaying and indicating AIS and radar tracking information should be consistent.

5.25 Target Tracking (TT) and Acquisition

5.25.1 General

Radar targets are sourced from the radar sensor (transceiver). The signals may be filtered (reduced) with the aid of the associated clutter controls. Radar targets may be manually or automatically acquired and tracked using an automatic Target Tracking (TT) facility.

5.25.1.1 The automatic target tracking calculations should be based on the measurement of radar target relative position and ownship motion.

5.25.1.2 Any other sources of information, when available, may be used to support the optimum tracking performance.

5.25.1.3 TT facilities should be available on at least the 3, 6, and 12nm range scales. Tracking range should extend to a minimum of 12nm.

5.25.1.4 The radar system should be capable of tracking targets having the maximum relative speed relevant to its classification for normal or high ownship speeds.

5.25.2 Tracked Target Capacity

5.25.2.1 In addition to the requirements for processing of targets reported by AIS, it should be possible to track and provide full presentation functionality for a minimum number of tracked radar targets according to table 1.

5.25.2.2 There should be an indication when the target tracking capacity is about to be exceeded. Target overflow should not degrade the radar system performance.

5.25.3 ***Acquisition***

5.25.3.1 Manual acquisition of radar targets should be provided with provision for acquiring at least the number of targets specified in table 1.

5.25.3.2 Automatic acquisition should be provided where specified in table 1. In this case, there should be means for the user to define the boundaries of the auto-acquisition area.

5.25.4 Tracking

5.25.4.1 When a target is acquired, the system should present the trend of the targets motion within one minute and the prediction of the targets' motion within 3 minutes.

5.25.4.2 TT should be capable of tracking and updating the information of all acquired targets automatically.

5.25.4.3 The system should continue to track radar targets that are clearly distinguishable on the display for 5 out of 10 consecutive scans.

5.25.4.4 The TT design should be such that target vector and data smoothing is effective, while target manoeuvres should be detected as early as possible.

5.25.4.5 The possibility of tracking errors, including target swap, should be minimized by design.

5.25.4.6 Separate facilities for cancelling the tracking of any one and of all target(s) should be provided.

5.25.4.7 Automatic tracking accuracy should be achieved when the tracked target has achieved a steady state, assuming the sensor errors allowed by the Organization:

5.25.4.7.1 For ships capable of up to 30kn true speed, the tracking facility should present, within 1 minute steady state tracking, the relative motion trend and after 3 minutes, the predicted motion of a target, within the following accuracy values (95% probability):

TABLE 3 – Tracked Target Accuracy (95% probability figures)

Time of steady state (minutes)	Relative Course (degrees)	Relative Speed (kn)	CPA (NM)	TCPA (minutes)	True Course (degrees)	True Speed (kn)
1min: Trend	11	1.5 or 10%	1.0	-	-	-
3min: Motion	3	0.8 or 1%	0.3	0.5	5	0.5 or 1%

Accuracy may be significantly reduced during or shortly after acquisition, ownship manoeuvre, a manoeuvre of the target, or any tracking disturbance and is also dependent on ownships motion and sensor accuracy.

Measured target range and bearing should be within 50m (or +/-1% of target range) and 2 degrees.

The testing standard should have detailed target simulation tests as a means to confirm the accuracy of targets with relative speeds of up to 100kn. Individual accuracy values shown in the table above may be adapted to account for the relative aspects of target motion with respect to that of ownship in the testing scenarios used.

5.25.4.7.2 For ships capable of speeds in excess of 30kn (typically HSC) and with speeds of up to 70kn, there should be additional steady state measurements made to ensure that the motion accuracy, after 3 minutes of steady state tracking, is maintained with target relative speeds of up to 140kn.

5.25.4.8 A ground referencing function, based on a stationary tracked target, should be provided. Targets used for this function should be marked with the relevant symbol.

5.26 Automatic Identification System (AIS) Reported Targets

5.26.1 General

Reported targets sourced from the AIS may be filtered according to user-defined parameters. Targets may be sleeping, or may be activated. Activated targets are treated in a similar way to radar tracked targets.

5.26.2 AIS Target Capacity

In addition to the requirements for radar tracking, it should be possible to display and provide full presentation functionality for a minimum number of sleeping and activated AIS targets according to table 1. There should be an indication when the capacity of processing / display of AIS targets is about to be exceeded.

5.26.3 Filtering of AIS Sleeping Targets

To reduce screen clutter, a means to filter the presentation of sleeping AIS targets should be provided, together with an indication of the filter status. (e.g. by target range, CPA/TCPA or AIS target class A/B, etc.). It should not be possible to remove individual AIS targets from the display.

5.26.4 Activation of AIS Targets

A means to activate a sleeping AIS target and to deactivate an activated AIS target should be provided. If zones for the automatic activation of AIS targets are provided, they should be the same as for automatic radar target acquisition. In addition, sleeping AIS targets may be automatically activated when meeting user defined parameters (e.g. target range, CPA/TCPA or AIS target class A/B).

5.26.5 AIS Presentation Status

TABLE 4 - The AIS presentation status should be indicated as follows:

Function	Cases to be Presented		Presentation
AIS ON / OFF	AIS processing switched ON / graphical presentation switched OFF	AIS processing switched ON / graphical presentation switched ON	Alphanumeric or graphical
Filtering of sleeping AIS targets	Filter status	Filter status	Alphanumeric or graphical
Activation of Targets		Activation criteria	Graphical
CPA/TCPA Alarm	Function ON/OFF Sleeping targets included	Function ON/OFF Sleeping targets included	Alphanumeric
Lost Target Alarm	Function ON/OFF Lost target Filter Criteria	Function ON/OFF Lost target Filter Criteria	Alphanumeric
Target Association	Function ON/OFF Association Criteria Default Target Priority	Function ON/OFF Association Criteria Default Target Priority	Alphanumeric

5.27 AIS Graphical Presentation

Targets should be presented with their relevant symbols according to MSC xx and SN/Circ [...].

5.27.1 AIS targets that are displayed should be presented as sleeping targets by default.

5.27.2 The course and speed of a tracked radar target or reported AIS target should be indicated by a predicted motion vector. The vector time should be adjustable and valid for presentation of any target regardless of its source.

5.27.3 A permanent indication of vector mode, time and stabilization should be provided.

5.27.4 The consistent common reference point should be used for the alignment of tracked radar and AIS symbols with other information on the same display.

5.27.5 On large scale / low range displays, a means to present the true scale outline of an activated AIS target should be provided. It should be possible to display the past track of activated targets.

5.28 AIS Target Data

5.28.1 It should be possible to select any tracked radar or AIS target for the alphanumeric display of its data. A target selected for the display of its alphanumeric information should be identified by the relevant symbol. If more than one target is selected for data display, the relevant symbols and the corresponding data should be clearly identified. There should be a clear indication to show that the target data is derived from radar or from AIS.

5.28.2 For each selected tracked radar target, the following data should be presented in alphanumeric form: source(s) of data, actual range of target, actual bearing of target, predicted target range at the closest point of approach (CPA), predicted time to CPA (TCPA), true course of target, true speed of target.

5.28.3 For each selected AIS target the following data should be presented in alphanumeric form: Source of data, ship's identification, navigational status, position and its quality, range, bearing, COG, SOG, CPA, and TCPA. Ships heading and rate of turn should be also be made available. Additional target information should be provided on request.

5.28.4 If the received AIS information is incomplete, the absent information should be clearly indicated as 'missing' within the target data field.

5.28.5 The data should be displayed and continually updated, until another target is selected for data display or until the window is closed.

5.28.6 Means should be provided to present ownship AIS data on request.

5.29 Operational Alarms

A clear indication of the cause for all alarm criteria should be given.

5.29.1 If the calculated CPA and TCPA values of a tracked target or activated AIS target are less than the set limits:

- A CPA / TCPA alarm should be given.
- The target should be clearly indicated.

5.29.2 The preset CPA/TCPA limits applied to targets from different sensors should be identical. As a default state, the CPA/TCPA alarm functionality should be applied to all activated AIS targets. On user request the CPA/TCPA alarm functionality may also be applied to sleeping targets.

5.29.3 If a user defined acquisition/activation zone facility is provided, a target not previously acquired/activated entering the zone, or is detected within the zone, should be clearly identified with the relevant symbol and an alarm should be given. It should be possible for the user to set ranges and outlines for the zone.

5.29.4 The system should alert the user if a tracked radar target is lost, rather than excluded by a pre-determined range or pre-set parameter. The target's last position should be clearly indicated on the display.

5.29.5 It should be possible to enable or disable the lost target alarm function for AIS targets. A clear indication should be given if the lost target alarm is disabled.

If the following conditions are met for a lost AIS target:

- The AIS lost target alarm function is enabled.
- The target is of interest, according to lost target filter criteria.
- A message is not received for a set time, depending on the nominal reporting rate of the AIS target.

Then:

- The last known position should be clearly indicated as a lost target and an alarm be given.
- The indication of the lost target should disappear if the signal is received again, or after the alarm has been acknowledged.
- A means of recovering limited historical data from previous reports should be provided.

5.30 AIS and Radar Target Association

An automatic target association function based on harmonized criteria's, serves to avoid the presentation of two target symbols for the same physical target.

5.30.1 If the target data from AIS and radar tracking are both available and if the association criteria (e.g. position, motion) are fulfilled such that the AIS and radar information are considered as one physical target, then as a default condition, the activated AIS target symbol and the alphanumeric AIS target data should be automatically selected and displayed.

5.30.2 The user should have the option to change the default condition to the display of tracked radar targets and should be permitted to select either radar tracking or AIS alphanumeric data.

5.30.3 For an associated target, if the AIS and radar information become sufficiently different, the AIS and radar information should be considered as two distinct targets and one activated AIS target and one tracked radar target should be displayed. No alarm should be raised.

5.31 Trial Manoeuvre

The system should, where required by table 1, be capable of simulating the predicted effects of ownships manoeuvre in a potential threat situation and should include ownship's dynamic characteristics. A trial manoeuvre simulation should be clearly identified. The requirements are:

- The simulation of ownship course and speed should be variable.
- A simulated time to manoeuvre with a countdown may be provided.
- During simulation, target tracking should continue and the actual target data should be indicated.
- Trial manoeuvre should be applied to all tracked targets and at least all activated reported targets.

5.32 The Display of Maps, Navigation Lines and Routes

5.32.1 It should be possible for the user to manually create and change, save, load and display simple maps/navigation lines/routes referenced to ownship or a geographical position. It should be possible to remove the display of this data by a single operator action.

5.32.2 The maps/navigation lines/routes may consist of lines, symbols and reference points.

5.32.3 The appearance of lines, colours and symbols are as defined in SN/Circ [...].

5.32.4 The maps/navigation lines/route graphics should not significantly degrade the radar information.

5.32.5 The maps/navigation lines/routes should be retained when the equipment is switched OFF.

5.32.6 The maps/navigation lines/route data should be transferable whenever a relevant equipment module is replaced.

5.33 The Display of Charts

5.33.1 The radar system may provide the means to display ENC and other chart information within the effective display area, to provide continuous and real-time position monitoring. It should be possible to remove the display of chart data by a single operator action.

5.33.2 The ENC information should be the primary source of information supplied in S57 format. Unofficial information should be identified with a permanent indication.

5.33.3 As a minimum, the elements of the ECDIS Display Base should be made available for individual selection by category or layer, but not as individual objects.

5.33.4 The chart information should use the same reference and co-ordinate criteria as the radar/AIS system.

5.33.5 The display of radar information should have priority. Chart information should be displayed such that radar information is not substantially masked, obscured or degraded. Chart information should be clearly perceptible as such.

5.33.6 A malfunction of the source of chart data should not affect the operation of the radar/AIS system.

5.33.7 Symbols and colours should comply with MSC [xx].

5.34 Alarms and Indications

Alarms and indications should comply with MSC [xx].

5.34.1 A means should be provided to alert the user of "picture freeze".

5.34.2 Failure of any primary signal or sensor, including; gyro, log, azimuth, video, sync and heading marker, should be alarmed. System functionality should be limited to a fall back mode or in some cases, the display presentation should be inhibited (see fallback modes, section 9).

5.35 Inter-Switching and Integrating Multiple Radars

5.35.1 The system should safeguard against single point system failure. If an inter-switch function is provided, a fail-safe condition should be applied in the event of a failure.

5.35.2 The source and any processing or combination of radar signals should be indicated.

5.35.3 The system status for each display position should be available.

6 ERGONOMIC CRITERIA

6.1 Operational Controls

6.1.1 The design should ensure that the radar system is simple to operate. Operational controls should have a harmonized user interface and be easy to identify and simple to use.

6.1.2 The radar system should be capable of being switched ON or OFF at the main system radar display or at a control position.

6.1.3 The control functions may be dedicated hardware, screen accessed or a combination of these; however the primary control functions should be dedicated hardware controls or soft keys, with an associated status indication in a consistent and intuitive position.

6.1.4 The following are defined as primary radar control functions and should be easily and immediately accessible:

Radar Standby / Run, Range scale selection, Gain, tuning function (if applicable), Anti-clutter rain, Anti-clutter sea, AIS function on/off, Alarm acknowledge, Cursor, a means to set EBL / VRM, display brightness and acquisition of radar targets.

6.1.5 The primary functions may also be operated from a remote operating position in addition to the main controls.

6.2 Display Presentation

6.2.1 The display presentation should comply with the Presentation Standard for Navigation Displays, MSC [xx].

6.2.2 The colours, symbols and graphics presented should comply with SN/Circ [xx].

6.2.3 The screen sizes should conform to those defined in table 1.

6.3 Instructions and Documentation

6.3.1 Documentation Language

The operating instructions and manufacturer's documentation should be written in a clear and comprehensible manner and should be available at least in the English language.

6.3.2 Operating Instructions

The operating instructions should contain a qualified explanation and/or description of information required by the user to operate the radar system correctly, including:

- appropriate settings for different weather conditions;
- monitoring the radar system's performance;
- operating in a failure or fall-back situation;

- limitations of the tracking process and accuracy, including any delays;
- using heading and SOG/COG information for collision avoidance;
- limitations and conditions of target merging and de-merging;
- criteria of selection for automatic activation and cancellation of targets;
- methods applied to display AIS targets, target association and any limitations;
- principles underlying the trial manoeuvre technology, including simulation of ownship's manoeuvring characteristics, if provided;
- alarms and indications;
- installation requirements as listed under section 7.5;
- radar range and bearing accuracies;
- any special operation (e.g. tuning) for the detection of SARTs.

6.3.3 Manufacturer's Documentation

6.3.3.1 The manufacturer's documentation should contain a description of the radar system and factors which may affect detection performance.

6.3.3.2 Documentation should describe the basis of AIS filter criteria and AIS/radar target association criteria.

6.3.3.3 The equipment documentation should include full details of installation information, including additional recommendations on unit location and factors that may degrade performance or reliability.

7 DESIGN AND INSTALLATION

7.1 Design for Servicing

7.1.1 As far as is practical, the radar system should be of a design to facilitate simple fault diagnosis and maximum availability.

7.1.2 The radar system should include a means to record the total operational hours for any components with a limited life.

7.1.3 The documentation should describe any routine servicing requirements and should include details of any restricted life components.

7.2 Display

The display device physical requirements should meet those specified in MSC [xx] and those specified in table 1.

7.3 Transceiver

The equipment should provide a mute facility to inhibit the transmission of radar energy over a preset sector. The mute sector should be set up on installation. An indication of sector mute status should be available.

7.4 Antenna

7.4.1 The antenna should be designed to start operating and to continue to operate in relative wind speeds likely to be encountered on the class of ship on which it is installed.

7.4.2 The combined radar system should be capable of providing an appropriate information update rate for the class of ship on which it is installed.

7.4.3 The antenna side lobes should be consistent with satisfying the system performance as defined in this standard.

7.4.4 There should be a means to prevent antenna rotation and radiation during servicing, or while personnel are in the vicinity of up-mast units.

7.5 Radar System Installation

Requirements and guidelines for the radar system installation should be included in the manufacturers' documentation. The following subjects should be covered:

7.5.1 The Antenna

Blind sectors should be kept to a minimum, and should not be placed in an arc of the horizon from the right ahead direction to 22.5^{o} abaft the beam and especially should avoid the right ahead direction (relative bearing 000^{o}). The installation of the antenna should be in such a manner that the performance of the radar system is not substantially degraded. The antenna should be mounted clear of any structure that may cause signal reflections, including other antenna and deck structure or cargo. In addition, the height of the antenna should take account of target detection performance relating to range of first detection and target visibility in sea clutter.

7.5.2 The Display

The orientation of the display should be such that the user is looking ahead, the lookout view is not obscured and there is minimum ambient light on the display screen.

7.6 Operation and Training

7.6.1 The design shall ensure that the radar system is simple to operate by trained users.

7.6.2 A target simulation facility should be provided for training purposes.

8 INTERFACING

8.1 Input Data

The radar system should be capable of receiving the required input information from:

- a gyro-compass or transmitting heading device (THD)
- a speed and distance measuring equipment (SAME)
- an electronic position fixing system (EPFS)
- an Automatic Identification System (AIS) or
- other sensors or networks providing equivalent information acceptable to the Organization.

The radar should be interfaced to relevant sensors required by this performance standard in accordance with recognized international standards.

8.2 Input Data Integrity and Latency

8.2.1 The radar system should not use data indicated as invalid. If input data is known to be of poor quality this should be clearly indicated.

8.2.2 As far as is practical, the integrity of data should be checked, prior to its use, by comparison with other connected sensors or by testing to valid and plausible data limits.

8.2.3 The latency of processing input data should be minimized.

8.3 Output Data

8.3.1 Information provided by any radar output interface to other systems should be in accordance with international standards[2].

8.3.2 The radar system should provide an output of the display screen data for the voyage data recorder (VDR).

8.3.3 At least one normally closed contact (isolated) should be provided for indicating failure of the radar.

8.3.4 The radar should have a bi-directional interface to facilitate communication so that alarms from the radar can be transferred to external systems and so that audible alarms from the radar can be muted from external systems, the interface should comply with relevant international standards.

[2] Refer to IEC publication 61162.

9 BACKUP AND FALLBACK ARRANGEMENTS

In the event of partial failures and to maintain minimum basic operation, the fallback arrangements listed below should be provided. There should be a permanent indication of the failed input information.

9.1 Failure of Heading Information (Azimuth Stabilization)

9.1.1 The equipment should operate satisfactorily in an unstabilized head-up mode.

9.1.2 The equipment should switch automatically to the unstabilized head up mode within 1 minute after the azimuth stabilization has become ineffective.

9.1.3 If automatic anti-clutter processing could prevent the detection of targets in the absence of appropriate stabilization, the processing should switch off automatically within 1 minute after the azimuth stabilization has become ineffective.

9.1.4 An indication should be given that only relative bearing measurements can be used.

9.2 Failure of Speed through the Water information

A means of manual speed input should be provided and its use clearly indicated.

9.3 Failure of Course and Speed Over Ground Information

The equipment may be operated with course and speed through the water information.

9.4 Failure of Position Input Information

The overlay of chart data and geographically referenced maps should be disabled if only a single TT reference target is defined and used, or the position is manually entered.

9.5 Failure of Radar Video Input Information

In the absence of radar signals, the equipment should display target information based on AIS data. A frozen radar picture should not be displayed.

9.6 Failure of AIS Input Information

In the absence of AIS signals, the equipment should display the radar video and target database.

Appendix 1 - References

IMO SOLAS Chapters IV, V and X	Carriage rules.
IMO Resolution A.278 (VII)	Supplement to the recommendation on PS for navigational radar equipment.
IMO Resolution A.424 (XI)	Performance standards for gyro-compasses.
IMO Resolution A.477 (XII)	Performance standards for radar equipment.
IMO Resolution A.694 (17)	General Requirements for ship borne radio equipment forming part of the global maritime distress and safety system and for electronically navigational aids.
IMO Resolution A.821 (19)	Performance standards for gyro-compasses for high-speed craft.
IMO Resolution A.824 (19)	Performance standards for devices to indicate speed and distance.
IMO Resolution MSC.86 (70)	Performance standards for INS.
IMO Resolution MSC.64 (67)	Recommendations on new and amended performance standards (Annex 2 revised by MSC.114 (73)).
IMO Resolution MSC.112 (73)	Revised performance standards for ship borne global positioning (GPS) receiver equipment.
IMO Resolution MSC.114 (73)	Revised performance standards for ship borne DGPS and DGLONASS maritime radio beacon receiver equipment.
IMO Resolution MSC.116 (73)	Performance standards for marine transmitting heading devices (THD).
IMO MSC Circ. 982 (20.12.2000)	Guidelines on ergonomic criteria for bridge equipment and layout.
IHO S-52 appendix 2:1997	Colour and symbol specification for ECDIS.
IEC 62388	Radar Test Standard (replacing 60872 and 60936 series of test standards).
IEC 60945	Maritime navigation and radio communication equipment and systems – General requirements – Methods of testing and required test results.
IEC 61162	Maritime navigation and radio communication equipment and systems – Digital interfaces.
IEC 62288	Presentation and display of navigation information.
ISO 9000 (all parts)	Quality management/assurance standards.

Appendix 2 – Definitions

Activated AIS target	A target representing the automatic or manual activation of a sleeping target for the display of additional graphically presented information. The target is displayed by an "activated target" symbol including: • a vector (COG / SOG); • the heading; and • ROT or direction of turn indication (if available) to indicate initiated course changes.
Acquisition of a Radar Target	Process of acquiring a target and initiating its tracking.
Activation of an AIS target	Activation of a sleeping AIS target for the display of additional graphical and alphanumerical information.
Acquired radar target	Automatic or manual acquisition initiates radar tracking. Vectors and past positions are displayed when data has achieved a steady state condition.
AIS	Automatic Information System.
AIS target	A target generated from an AIS message**.** See activated target, lost target, selected target and sleeping target.
Associated target	If an acquired radar target and an AIS reported target have similar parameters (e.g. position, course, speed) comply with an association algorithm, they are considered to be the same target and become an associated target.
Acquisition / Activation zone	A zone set up by the operator in which the system should automatically acquire radar targets and activate reported AIS targets when .entering the zone.
AtoN (real)	Aid to Navigation, in this context transmitting an AIS signal (e.g. a buoy).
AtoN (virtual)	Aid to Navigation, in this context generated by an AIS signal and not physically existing.
Bow crossing range	Distance from the common reference position to the point where a target is predicted to cross own ship's heading line.
Bow passing prediction	Pre-calculated time and distance to the point where a target is predicted to cross own ship's heading line.
CCRP	Consistent Common Reference Point: A location on ownship, to which all horizontal measurements such as target range, bearing, relative course, relative speed, closest point of approach (CPA) or time to closest point of approach (TCPA) are referenced, typically the conning position of the bridge.

CPA/TCPA	Closest Point of Approach / Time to the Closest Point of Approach: Distance to the closest point of approach (CPA) and time to the closest point of approach (TCPA). Limits are set by the operator related to own ship.
Course Over Ground (COG)	Direction of the ship's movement relative to the earth, measured on board the ship, expressed in angular units from true north.
Course Through Water (CTW)	Direction of the ship's movement through the water, defined by the angle between the meridian through its position and the direction of the ship's movement through the water, expressed in angular units from true north.
Dangerous Target	A target whose predicted CPA and TCPA are violating the values as preset by the operator. The respective target is marked by a "dangerous target" symbol.
Display modes	**Relative motion:** means a display on which the position of own ship remains fixed, and all targets move relative to own ship. **True motion:** a display across which own ship moves with its own true motion.
Display orientation	**North up display:** an azimuth stabilized presentation which uses the gyro input and north is upper most on the presentation. **Course up display:** an azimuth stabilized presentation which uses the gyro input and the ship's course is upper most on the presentation at the time of selection. **Head up display:** an unstabilized presentation in which own ship's heading is upper most on the presentation.
ECDIS	Electronic Chart Display and Information System.
Effective display area	Area of the display presenting the situation display, excluding the user dialog area.
EPFS	Electronic Position Fixing System.
ERBL	Electronic bearing line carrying a marker, which is combined with the range marker, used to measure range and bearing from own ship or between two objects.
Heading	Direction in which the bow of a ship is pointing expressed as an angular displacement from north.
HSC	High-speed craft (HSC) are vessels which comply with the definition in SOLAS for high speed vessels.
Lost AIS target	A target representing the last valid position of an AIS target before the reception of its data was lost. The target is displayed by a "lost AIS target" symbol.
Lost radar target	Target information is no longer available due to poor, lost or obscured signals. The target is displayed by a "lost radar

	target" symbol.
Maps / Nav Lines	Operator defined or created lines to indicate channels, Traffic Separation Schemes or borders of any area important for navigation.
Past positions	Equally time-spaced past position marks of a tracked or reported target and own ship. The past positions' track may be either relative or true.
Radar	(**Ra**dio **d**irection **a**nd **r**anging) A radio system that allows the determination of distance and direction of reflecting objects and of transmitting devices.
Radar beacon	A navigation aid which responds to the radar transmission by generating a radar signal to identify its position and identity.
Radar composite system	An equipment to transmit radio microwave signals, receive, process and display both radar signals and information from other sources such as AIS and SENC data.
Radar target	Any object fixed or moving whose position and motion is determined by successive radar measurements of range and bearing.
Reference target	Symbol indicating that the associated tracked stationary target (e.g. a navigational mark) is used as a speed reference for the ground stabilization.
Relative bearing	Direction of a target's position from own ship's reference location expressed as an angular displacement from own ship's heading.
Relative course	Direction of motion of a target relative to own ship's direction. (Bearing).
Relative motion	Combination of relative course and relative speed.
Relative speed	Speed of a target relative to own ship's speed data.
Rate Of Turn	Change of heading per time unit.
SART	Search And Rescue Transponder.
SDME	Speed and Distance Measurement Equipment.
SENC	**System electronic navigational chart (SENC)** means a database resulting from the transformation of the ENC by ECDIS for appropriate use, updates to the ENC by appropriate means, and other data added by the mariner. It is this database that is actually accessed by ECDIS for the display generation and other navigational functions, and is the equivalent to an up-to-date paper chart. The SENC may also contain information from other.
Selected target	A manually selected target for the display of detailed alphanumeric information in a separate data display area. The target is displayed by a "selected target" symbol.

Sleeping AIS target	A target indicating the presence and orientation of a vessel equipped with AIS in a certain location. The target is displayed by a "sleeping target" symbol. No additional information is presented until activated.
Stabilization modes	**Ground stabilization:** Display mode in which speed and course information are referred to the ground, using ground track input data, or EPFS as reference. **Sea stabilization:** Display mode in which speed and course information are referred to the sea, using gyro and water speed log input as reference.
Standard radar reflector	Reference reflector mounted 3.5 m above sea level with 10 m^2 effective reflecting area.
Steady state tracking	Tracking a target, proceeding at steady motion - after completion of the acquisition process, or - without a manoeuvre of target or own ship, or - without target swap or any disturbance.
Speed Over Ground (SOG)	Speed of the ship relative to the earth, measured on board of the ship.
SOLAS	Safety Of Life At Sea.
Suppressed area	An area set up by the operator within which targets are not acquired.
Target swap	Situation in which the incoming radar data for a tracked target becomes incorrectly associated with another tracked target or a non-tracked radar echo.
Target's predicted motion	Prediction of a target's future course and speed based on linear extrapolation from its present motion as determined by past measurements of its range and bearing on the radar.
Target Tracking (TT)	Computer process of observing the sequential changes in the position of a radar target in order to establish its motion.
Trails	Tracks displayed by the radar echoes of targets in the form of an afterglow. Trails may be true or relative.
Trial manoeuvre	Graphical simulation facility used to assist the operator to perform a proposed manoeuvre for navigation and collision avoidance purposes, by displaying the predicted future status of at least all acquired or activated targets as a result of own ship's simulated manoeuvres.
True bearing	Direction of a target from own ship's reference location or from another target's position expressed as an angular displacement from true north.
True course	Direction of motion relative to ground or to sea, of a target expressed as an angular displacement from north.
True motion	Combination of true course and true speed.

True speed	Speed of a target relative to ground, or to sea.
Vector modes	**True vector:** Vector representing the predicted true motion of a target, showing course and speed with reference to the ground. **Relative vector:** Predicted movement of a target relative to own ship's motion.
User Configured Presentation	A display presentation configured by the user for a specific task at hand. The presentation may include radar and/or chart information, in combination with other navigation or ship related data.
User Dialog Area	Is an area of the display consisting of data fields and/or menus that is allocated to the interactive presentation and entry or selection of operational parameters, data and commands mainly in alphanumeric form.

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